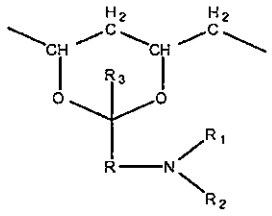
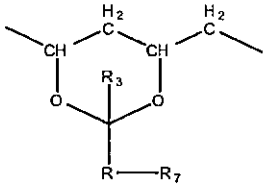
What is claimed is:

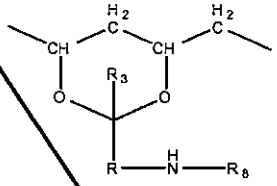
1. A method for producing a contact lens, comprising: the steps of:
   (1) introducing a fluid composition into a mold for making a contact lens, wherein the fluid composition comprises a lens-forming material and a Butylated Polyvinylpyrrolidone, wherein the lens-forming material is crosslinkable and/or polymerizable by actinic radiation or by heating;
   (2) crosslinking/polymerizing the lens-forming material in the mold to form a lens having a polymer matrix; and
   (3) separating the mold, wherein the Butylated Polyvinylpyrrolidone present in an amount sufficient to reduce an averaged mold separation force by at least about 20% in comparison with that without the Butylated Polyvinylpyrrolidone.
2. The method of claim 1, wherein the Butylated Polyvinylpyrrolidone having a molecular weight of from about 8000 Da to 30,000 Da.
3. The method of claim 1, wherein the Butylated Polyvinylpyrrolidone having a molecular weight of about 12,000 Da to 22,000 Da.
4. The method of claim 1, wherein the lens-forming material comprises at least one prepolymer.
5. The method of claim 4, wherein the prepolymer is a silicone-containing prepolymer or a silicone-free prepolymer.
6. The method of claim 5, wherein the prepolymer is a water-soluble silicone-free prepolymer.
7. The method of claim 6, wherein the prepolymer is a water-soluble crosslinkable poly(vinyl alcohol) prepolymer, a water-soluble vinyl group-terminated polyurethane, a water-soluble crosslinkable polyurea prepolymer, a crosslinkable polyacrylamide, a crosslinkable statistical copolymer of vinyl lactam, MMA and a comonomer, a crosslinkable copolymer of vinyl lactam, vinyl acetate and vinyl alcohol, a polyether-polyester copolymer with crosslinkable side chains, a branched polyalkylene glycol-urethane prepolymer, a polyalkylene glycol-tetra(meth)acrylate prepolymer, or a crosslinkable polyallylamine gluconolactone prepolymer.
8. The method of claim 7, wherein the prepolymer is a polyhydroxyl compound which has a molecular weight of at least about 2000 and comprises from about 0.5 to about 80%, based on the number of hydroxyl groups in the poly(vinyl alcohol), of units of the formula I, I and II, I and III, or I and II and III



I



II



III

wherein R is alkylene having up to 12 carbon atoms; R_1 is hydrogen or lower alkyl having up to seven carbon atoms; R_2 is an olefinically unsaturated, electron-withdrawing, crosslinkable radical having up to 25 carbon atoms; R_3 is hydrogen, a C_1 -C_6 alkyl group or a cycloalkyl group; R_7 is a primary, secondary or tertiary amino group or a quaternary amino group of the formula $N^+(R')_3X^-$, in which each R', independently of the others, is hydrogen or a C_1 -C_4 alkyl radical and X is a counterion selected from the group consisting of HSO_4^-, F^-, Cl^-, Br^-, I^-, CH_3COO^-, OH^-, BF^-, and $H_2PO_4^-$; and R_8 is the radical of a monobasic, dibasic or tribasic, saturated or unsaturated, aliphatic or aromatic organic acid or sulfonic acid.

9. The method of claim 8, wherein the prepolymer is a water-soluble crosslinkable polyurea prepolymer having a formula

Q——CP——Q (4)

wherein Q is an organic radical that comprises at least one crosslinkable group and CP is a bivalent copolymer fragment consisting of the segments A, B and T, provided that a segment A or B is always followed by a segment T which is followed by a segment A or B in the copolymer fragment CP and that the radical Q in formula (4) is bonded to a segment A or B;

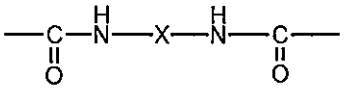
wherein the segment A is a bivalent radical of formula

——R_{14}N——A_1——NR_{14}'—— (5a)

in which A_1 is the bivalent radical of a polyalkylene glycol or is a linear or branched alkylene radical having from 2 to 24 carbon atoms and each of R_{14} and R_{14}' independently of the other is hydrogen or unsubstituted or substituted C_1-C_6alkyl or,

in the case of the amino group that terminates the copolymer fragment, may also be a direct, ring-forming bond;

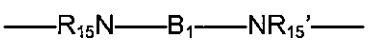
wherein the segment T is a bivalent radical of formula



(5b)

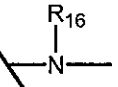
in which X is a bivalent aliphatic, cycloaliphatic, aliphatic-cycloaliphatic, aromatic, araliphatic or aliphatic-heterocyclic radical.

wherein the segment B is a radical of formula



(5c)

in which each of R_{15} and R_{15}' independently of the other has the meanings given above for R_{14}, B_1 is a bivalent aliphatic, cycloaliphatic, aliphatic-cycloaliphatic, aromatic or araliphatic hydrocarbon radical that is interrupted by at least one amine group of formula



(6),

in which R_{16} is hydrogen, a radical Q mentioned above or a radical of formula



(7),

in which Q is as defined above, and CP' is a bivalent copolymer fragment independently consisting of at least two of the above-mentioned segments A, B and T, provided that a segment A or B is always followed by a segment T which is followed by a segment A or B in the copolymer fragment CP', that the radical Q in formula (7) is bonded to a segment A or B in each case and that the N atom in formula (6) is bonded to a segment T when R_{16} is a radical of formula (7).

10. The method of claim 1, wherein the step of crosslinking and/or polymerizing is performed under a spatial limitation of actinic radiation to form a contact lens having a first surface, an opposite second surface, and an edge, wherein the mold is a reusable mold having two molding surfaces, wherein the first and second surfaces are defined by the two molding surface, and the edge is defined by the spatial limitation of actinic radiation.

11. A method for improving quality and production yield of contact lenses, comprising the steps of: adding a Butylated Polyvinylpyrrolidone into a fluid composition including a lens-forming material in an amount sufficient to reduce an averaged mold separation force by at least about 20% in comparison with that without the Butylated Polyvinylpyrrolidone, wherein the lens-forming material is crosslinkable and/or polymerizable by actinic radiation or by heating in a mold to form a contact lens having a polymer matrix.

12. A fluid composition for making contact lenses, comprising: a lens-forming material and a Butylated Polyvinylpyrrolidone, wherein the lens-forming material is crosslinkable and/or polymerizable by actinic radiation in a mold to form a contact lens having a polymer matrix, wherein the Butylated Polyvinylpyrrolidone is present in an amount sufficient to reduce an averaged mold separation force by at least about 20% in comparison with that without the Butylated Polyvinylpyrrolidone.

CLAIMS

1. A method for producing a contact lens, comprising: the steps of:

(1) introducing a fluid composition into a mold for making a contact lens, wherein the fluid composition comprises a lens-forming material and a Butylated Polyvinylpyrrolidone, wherein the lens-forming material is crosslinkable and/or polymerizable by actinic radiation or by heating;

(2) crosslinking/polymerizing the lens-forming material in the mold to form a lens having a polymer matrix; and

(3) separating the mold, wherein the Butylated Polyvinylpyrrolidone present in an amount sufficient to reduce an averaged mold separation force by at least about 20% in comparison with that without the Butylated Polyvinylpyrrolidone.

2. The method of claim 1, wherein the Butylated Polyvinylpyrrolidone having a molecular weight of from about 8000 Da to 30,000 Da.

3. The method of claim 1, wherein the Butylated Polyvinylpyrrolidone having a molecular weight of about 12,000 Da to 22,000 Da.

4. The method of claim 1, wherein the lens-forming material comprises at least one prepolymer.

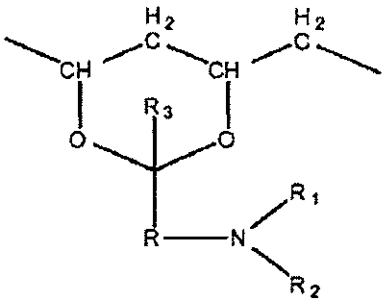
5. The method of claim 4, wherein the prepolymer is a silicone-containing prepolymer or a silicone-free prepolymer.

6. The method of claim 5, wherein the prepolymer is a water-soluble silicone-free prepolymer.

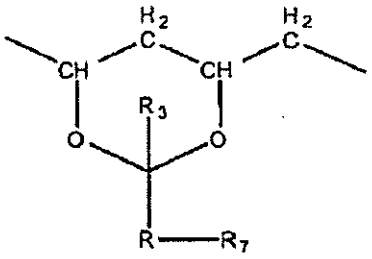
7. The method of claim 6, wherein the prepolymer is a water-soluble crosslinkable poly(vinyl alcohol) prepolymer, a water-soluble vinyl group-terminated polyurethane, a water-soluble crosslinkable polyurea prepolymer, a crosslinkable polyacrylamide, a crosslinkable statistical copolymer of vinyl lactam, MMA and a comonomer, a crosslinkable copolymer of vinyl lactam, vinyl acetate and vinyl alcohol, a polyether-polyester copolymer with crosslinkable side chains, a branched polyalkylene glycol-urethane prepolymer, a

polyalkylene glycol-tetra(meth)acrylate prepolymer, or a crosslinkable polyallylamine gluconolactone prepolymer.

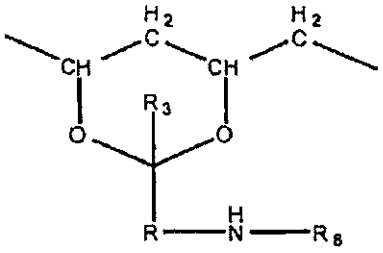
8. The method of claim 7, wherein the prepolymer is a polyhydroxyl compound which has a molecular weight of at least about 2000 and comprises from about 0.5 to about 80%, based on the number of hydroxyl groups in the poly(vinyl alcohol), of units of the formula I, I and II, I and III, or I and II and III



I



II



III

wherein R is alkylene having up to 12 carbon atoms; R_1 is hydrogen or lower alkyl having up to seven carbon atoms; R_2 is an olefinically unsaturated, electron-withdrawing, crosslinkable radical having up to 25 carbon atoms; R_3 is hydrogen, a C_1 -C_6 alkyl group or a cycloalkyl group; R_7 is a primary, secondary or tertiary amino group or a quaternary amino group of the formula $N^+(R')_3X^-$, in which each R', independently of the others, is hydrogen or a C_1 -C_4 alkyl radical and X is a counterion selected from the group consisting of HSO_4^-, F^-, Cl^-, Br^-, I^-, CH_3COO^-, OH^-, BF^-, and $H_2PO_4^-$; and R_8 is the radical of a monobasic, dibasic or tribasic, saturated or unsaturated, aliphatic or aromatic organic acid or sulfonic acid.

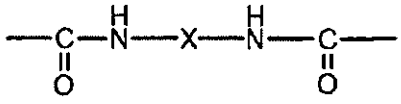
9. The method of claim 8, wherein the prepolymer is a water-soluble crosslinkable polyurea prepolymer having a formula

$$Q\text{-}CP\text{-}Q \qquad (4)$$

wherein Q is an organic radical that comprises at least one crosslinkable group and CP is a bivalent copolymer fragment consisting of the segments A, B and T, provided that a segment A or B is always followed by a segment T which is followed by a segment A or B in the copolymer fragment CP and that the radical Q in formula (4) is bonded to a segment A or B; wherein the segment A is a bivalent radical of formula

$$-R_{14}N\text{-}A_1\text{-}NR_{14}'\text{-} \qquad (5a)$$

in which A_1 is the bivalent radical of a polyalkylene glycol or is a linear or branched alkylene radical having from 2 to 24 carbon atoms and each of R_{14} and R_{14}' independently of the other is hydrogen or unsubstituted or substituted C_1-C_6alkyl or, in the case of the amino group that terminates the copolymer fragment, may also be a direct, ring-forming bond; wherein the segment T is a bivalent radical of formula

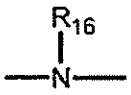


(5b)

in which X is a bivalent aliphatic, cycloaliphatic, aliphatic-cycloaliphatic, aromatic, araliphatic or aliphatic-heterocyclic radical.
wherein the segment B is a radical of formula

$$-R_{15}N\text{-}B_1\text{-}NR_{15}'\text{-} \qquad (5c)$$

in which each of R_{15} and R_{15}' independently of the other has the meanings given above for R_{14}, B_1 is a bivalent aliphatic, cycloaliphatic, aliphatic-cycloaliphatic, aromatic or araliphatic hydrocarbon radical that is interrupted by at least one amine group of formula



(6),

in which R_{16} is hydrogen, a radical Q mentioned above or a radical of formula

$$Q\text{-}CP'\text{-} \qquad (7),$$

in which Q is as defined above, and CP' is a bivalent copolymer fragment independently consisting of at least two of the above-mentioned segments A, B and T, provided that a segment A or B is always followed by a segment T which is followed by a segment A or B in the copolymer fragment CP', that the radical Q in formula (7) is bonded to a segment A or B in each case and that the N atom in formula (6) is bonded to a segment T when R_{16} is a radical of formula (7).

10. The method of claim 1, wherein the step of crosslinking and/or polymerizing is performed under a spatial limitation of actinic radiation to form a contact lens having a first surface, an opposite second surface, and an edge, wherein the mold is a reusable mold having two molding surfaces, wherein the first and second surfaces are defined by the two molding surface, and the edge is defined by the spatial limitation of actinic radiation.

11. A method for improving quality and production yield of contact lenses, comprising the steps of: adding a Butylated Polyvinylpyrrolidone into a fluid composition including a lens-forming material in an amount sufficient to reduce an averaged mold separation force by at least about 20% in comparison with that without the Butylated Polyvinylpyrrolidone, wherein the lens-forming material is crosslinkable and/or polymerizable by actinic radiation or by heating in a mold to form a contact lens having a polymer matrix.

12. A fluid composition for making contact lenses, comprising: a lens-forming material and a Butylated Polyvinylpyrrolidone, wherein the lens-forming material is crosslinkable and/or polymerizable by actinic radiation in a mold to form a contact lens having a polymer matrix, wherein the Butylated Polyvinylpyrrolidone is present in an amount sufficient to reduce an averaged mold separation force by at least about 20% in comparison with that without the Butylated Polyvinylpyrrolidone.